

What is claimed is:

1. A transmitter in a multi-carrier transmission system for conducting communications using a modulation method for dividing a transmission band into a plurality of sub-carriers and mapping each sub-carrier using a complex signal point expressed by  $k$  bits, comprising: an encoding unit converting transmitting data information, the number of bits of which is smaller than  $kn$  bits, which are data used to express  $n$  sub-carriers, into a signal point pattern, in which the peak power of a transmitting signal is small, of signal point patterns expressed by the  $kn$  bits, the encoding unit further comprising a sub-carrier generation unit generating sub-carriers composed of signal points in which the signal point pattern with a small peak power is divided into two orthogonal groups in four quadrants of an IQ plane and in which the signal point of the part of sub-carriers has a prescribed correlation with a signal point of another sub-carrier; and a mapping unit generating transmitting signals of  $n$  sub-carriers using an output of the encoding unit.

2. The transmitter in a multi-carrier transmission system according to claim 1, wherein



system according to claim 2, wherein

said sub-carrier generation unit comprises a ROM.

7. A four-sub-carrier transmitter for 4m  
5 sub-carriers providing m transmitters, each of which  
comprises both the said encoding unit and mapping unit  
according to claim 1, in parallel and independently.

8. A receiver in a multi-carrier transmission system  
10 for conducting communications using a modulation method  
for dividing a transmission band into a plurality of  
sub-carriers and mapping each sub-carrier using a  
complex signal point expressed by k bits, comprising:

a demapping unit converting receiving signals  
15 obtained by converting transmitting data information,  
the number of bits of which is smaller than kn bits,  
which are data used to express n sub-carriers, into a  
signal point pattern, in which the peak power of a  
transmitting signal is small, of signal point patterns  
20 expressed by the kn bits and transmitted from a  
transmitting side;

a mapping signal generation unit generating all  
signal point patterns that might be transmitted from  
the transmitting side; and

25 a hard-decision decoding unit further comprising

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a comparison unit comparing signal point patterns of an output of the demapping unit with signal point patterns of an output of the mapping signal generation unit and an output unit outputting data corresponding to one signal point pattern, in which the signal point pattern outputted from the demapping unit and the signal point pattern outputted from the mapping signal generation unit are matched.

10 9. The receiver in a multi-carrier transmission system according to claim 8, wherein said mapping signal generation unit further comprises:

a timing control unit, including a counter sequentially generating information bits of less than 2k when decoding n sub-carrier signals;

an encoding unit inputting information bits outputted from a timing control unit and converting the information bits into a signal point pattern, in which the peak power of a transmitting signal is small, of signal point patterns expressed by 2k bits, the encoding unit further comprising a sub-carrier generation unit generating sub-carriers composed of signal points in which the signal point pattern with small peak power is divided into two orthogonal groups in four quadrants of an IQ plane and in which a signal point of a part

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of sub-carriers has a prescribed correlation with a signal point of another sub-carrier.

10. The receiver in a multi-carrier transmission system according to claim 9, further comprising:

5 a transmission error detection unit detecting a transmission error when detecting a receiving signal that does not belong to any of the signal point patterns that might be transmitted from a transmitting side, of  
10 outputs of said demapping unit; and

a decoding operation stoppage control unit stopping a decoding operation by said hard-decision decoding unit when said transmission error detection unit detects a transmission error.

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11. A receiver in a multi-carrier transmission system for conducting communications using a modulation method for dividing a transmission band into a plurality of sub-carriers and mapping each sub-carrier using a  
20 complex signal point expressed by  $k$  bits, comprising:

a demapping unit converting a receiving signal obtained by converting transmitting data information, the number of bits of which is smaller than  $kn$  bits, which are data used to express  $n$  sub-carriers, into a  
25 signal point pattern, in which the peak power of a

transmitting signal is small, of signal point patterns expressed by the  $kn$  bits and transmitted from a transmitting side by a sub-carrier composed of signal points in which the signal point pattern with small peak power is divided into two orthogonal groups in four quadrants of an IQ plane and in which a signal point of a part of sub-carriers has a prescribed correlation with a signal point of another sub-carrier, into a demapping signal used to be compared with all signal point patterns that might be transmitted from the transmitting side;

a transmission error detection unit detecting a transmission error when detecting a receiving signal that does not belong to any of the signal point patterns that might be transmitted from the transmitting side, of outputs of the demapping unit.

12. The receiver in a multi-carrier transmission system according to claim 11, wherein said error detection unit comprises a logical circuit.

13. The receiver in a multi-carrier transmission system according to claim 11, wherein said error detection unit comprises a ROM.

14. A receiver in a multi-carrier transmission system for conducting communications using a modulation method for dividing a transmission band into a plurality of sub-carriers and mapping each sub-carrier using a complex signal point expressed by  $k$  bits, comprising:

5 a mapping unit mapping all signal point patterns that can be expressed by  $kn$  bits in relation to  $n$  sub-carriers and that might be transmitted from a transmitting side in order to convert the signal point patterns into respective transmitting signals of  $n$  sub-carriers, as in the transmitting side and outputting a transmission availability signal; and

10 a soft-decision decoding unit further comprising an output unit outputting a signal point pattern before the mapping of a transmission availability signal with the shortest code distance of code distances between a receiving signal obtained by converting transmitting data information, the number of bits of which is smaller than  $kn$  bits, which are data used to express  $n$  sub-carriers, into a signal point pattern, in which the peak power of a transmitting signal is small, of signal point patterns expressed by the  $kn$  bits and transmitted from a transmitting side by a sub-carrier composed of signal points in which the signal point pattern with

20 small peak power can be divided into two orthogonal

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groups in four quadrants of an IQ plane and having a sub-carrier generation unit generating sub-carriers in which a signal point of a part of sub-carriers has a prescribed correlation with a signal point of another sub-carrier, and all the transmission availability signals as a decoding signal.

15. The receiver in a multi-carrier transmission system according to claim 14, wherein said output unit further comprising:

a code distance calculation unit calculating a distance between a receiving data signal and an output of said mapping unit;

a minimum distance memory unit storing a minimum code distance;

a code distance comparison unit comparing an output of the minimum distance memory unit and an output of the code distance calculation unit and updating said minimum distance memory unit when a code distance is shorter than the distance stored in the minimum distance memory unit; and

a memory unit outputting data corresponding to the minimum distance as decoding data.

16. The receiver in a multi-carrier transmission



system according to claim 11, further comprising  
an error correction decoding unit performing  
error correction decoding of a receiving data signal  
using code distances between the receiving signal and  
5 all the transmission availability signals.

17. A transmitting method in a multi-carrier  
transmission system for conducting communications  
using a modulation method for dividing a transmission  
10 band into a plurality of sub-carriers and mapping each  
sub-carrier using a complex signal point expressed by  
k bits, comprising:

generating a sub-carrier composed of signal  
points in which the signal point pattern with small peak  
15 power can be divided into two orthogonal groups in four  
quadrants of an IQ plane and has a sub-carrier generation  
unit generating sub-carriers in which a signal point  
of a part of sub-carriers has a prescribed correlation  
with a signal point of another sub-carrier when  
20 converting receiving signals obtained by converting  
transmitting data information, the number of bits of  
which is smaller than  $kn$  bits, which are data used to  
express  $n$  sub-carriers, into a signal point pattern,  
in which the peak power of a transmitting signal is small,  
25 of signal point patterns expressed by the  $kn$  bits; and

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generating transmitting signals by mapping the encoding result.

18. A receiving method in a multi-carrier  
5 transmission system for conducting communications using a modulation method for dividing a transmission band into a plurality of sub-carriers and mapping each sub-carrier using a complex signal point expressed by  $k$  bits, comprising:

10 converting a receiving signal obtained by converting transmitting data information, the number of bits of which is smaller than  $kn$  bits, which are data used to express  $n$  sub-carriers, into a signal point pattern, in which the peak power of a transmitting signal  
15 is small, of signal point patterns expressed by the  $kn$  bits and transmitted from a transmitting side by a sub-carrier composed of signal points in which the signal point pattern with small peak power can be divided into two orthogonal groups in four quadrants of an IQ  
20 plane and having a sub-carrier generation unit generating sub-carriers in which a signal point of a part of sub-carriers has a prescribed correlation with a signal point of another sub-carrier, into demapping signals (demapping step);

25 generating all signal point patterns that might

be transmitted from the transmitting side (mapping signal generation step); and

comparing signal point patterns of an output of the demapping step and signal point patterns of an output of the mapping signal generation step (comparison step) and outputting the transmitting data information corresponding to one signal point pattern, in which the signal point pattern outputted from the demapping unit and the signal point pattern outputted from the mapping signal generation unit are matched, as a decoding data signal.

19. A receiving method in a multi-carrier transmission system for conducting communications using a modulation method for dividing a transmission band into a plurality of sub-carriers and mapping each sub-carrier using a complex signal point expressed by  $k$  bits, comprising:

mapping all signal point patterns that can be expressed by  $kn$  bits in relation to  $n$  sub-carriers and that might be transmitted from a transmitting side in order to convert the signal point patterns into respective transmitting signals of  $n$  sub-carriers, as in the transmitting side and outputting a transmission availability signal (mapping step); and

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outputting the signal point pattern before mapping of the transmission availability signal with the shortest code distance of code distances between a receiving signal obtained by converting transmitting data information, the number of bits of which is smaller than  $kn$  bits, which are data used to express  $n$  sub-carriers, into the signal point pattern, in which the peak power of a transmitting signal is small, of signal point patterns expressed by the  $kn$  bits and transmitted from a transmitting side by a sub-carrier composed of signal points in which the signal point pattern with small peak power can be divided into two orthogonal groups in four quadrants of an IQ plane and having a sub-carrier generation sub-unit generating sub-carriers in which the signal point of a part of sub-carriers has a prescribed correlation with the signal point of another sub-carrier, and all the transmission availability signals as a decoding signal (output step) (soft-decision decoding step).

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20. A transmitter in a multi-carrier transmission system for conducting communications using a modulation method for dividing a transmission band into a plurality of sub-carriers and mapping each sub-carrier using a complex signal point expressed by  $k$  bits, comprising:

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an encoding unit converting transmitting data information, the number of bits of which is smaller than  $kn$  bits, which are data used to express  $n$  sub-carriers, into a signal point pattern, in which the peak power of a transmitting signal is small, of signal point patterns expressed by the  $2k$  bits, the encoding unit further comprising a sub-carrier generation unit generating the sub-carrier in which the signal point with small peak power can be divided into two orthogonal groups in four quadrants of an IQ plane and in which the signal point of a part of sub-carriers has a prescribed correlation with the signal point of another sub-carrier.

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